PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : G02B 5/18, 6/16, 6/293, G02F 1/225 — A1

(11) International Publication Number: **WO 98/59267**

(43) International Publication Date: 30 December 1998 (30.12.98)

(21) International Application Number: PCT/AU98/00473

(22) International Filing Date: 18 June 1998 (18.06.98)

(30) Priority Data:
PO 7458 19 June 1997 (19.06.97) AU

(71) Applicant *(for all designated States except US)*: UNIPHASE FIBRE COMPONENTS PTY, LIMITED [AU/AU]; 101 National Innovation Centre, Australian Technology Park, Cornwallis Street, Eveleigh, NSW 1430 (AU).

(72) Inventors; and

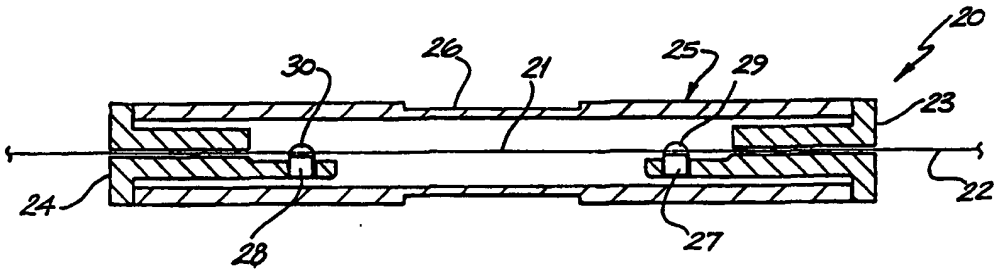
(75) Inventors/Applicants *(for US only)*: BULMAN, Jonathan, Mark [GB/AU]; 33 Illiliwa Street, Cremorne, NSW 2090 (AU). INGLIS, Hugh, Gregory [AU/AU]; 264 Ellesmere Road, Gymea Bay, NSW 2227 (AU).

(74) Agent: GRIFFITH HACK; Patent and Trade Mark Attorneys, G.P.O. Box 4164, Sydney, NSW 2001 (AU).

(81) Designated States: AU, CA, JP, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: TEMPERATURE STABLE BRAGG GRATING PACKAGE WITH POST TUNING FOR ACCURATE SETTING OF CENTRE FREQUENCY



(57) Abstract

A method of accurately setting the centre wavelength of a fibre grating fixed in a temperature compensation package, the method comprising the steps of: fixing the grating to the package and altering the size of the package in a post processing step. The altering step can comprise elongating or compressing the package so as to substantially permanently alter the size of the package. The temperature compensation package can comprise: a first elongated member having a first coefficient of thermal expansion; two second elongated members, one each attached to the ends of the first elongated member and having their other second ends closer together than the ends of the first elongated member, the second elongated members having a second coefficient of thermal expansion relatively more than the first coefficient of thermal expansion; and two material matching members attached to the second ends and adapted to provide for material matching fixing mixtures to the second elongated members; said fixing mixtures to the second elongated members; said fixing mixtures fixing ends of the fibre grating to the temperature compensation package. The fixing mixture can comprise glass of metal solder. The material matching members are preferably located within an aperture in the second ends.

Temperature Stable Bragg Grating Package with Post Tuning for Accurate Setting of Centre Frequency

Field of the Invention

The present invention relates to the construction of a package for an optical fibre Bragg grating so as to facilitate accurate setting of the centre frequency. The preferred embodiment including a package which provides a stable centre frequency at a range of temperatures.

Background of the Invention

Bragg gratings are well known in the field of optical fibre construction and normally comprise a repeating pattern written into a photosensitive optical fibre by a UV light source or the like. Unfortunately, the modulating pattern is normally inherently highly sensitive to the effects of strain and temperature. This is a disadvantage in that in applications, such as communications or sensing systems, it is often a requirement that the optical characteristics of the grating are not influenced by the effects of temperature or strain. For this reason, it is a typical requirement to mount the grating in a package so as to isolate the grating region from external strain or temperature effects.

In Fig. 1, there is shown a simple grating package 1 which mounts a fibre 2 at two ends of a package mount 3 by means of fixing with epoxy 4. Unfortunately, with this arrangement expansion of the package 3 with temperature relative to the fibre 2 will result in a change in tension on the fibre 2.

In Fig. 2, there is shown a slightly more complex arrangement 10 which includes a temperature compensating package which uses a combination of materials with differing thermal expansions. A first material 11 is utilised to expand at a first low rate while a second material comprising end portions 12, 13 expands with temperature at a substantially higher rate. The combined

expansions of the two forms of material 11, 12 and 13 produces a more stable arrangement whereby the fibre fixing points 15, 16 are maintained thereby maintaining the overall strain on the fibre 18 in the intermediate region so as to counteract the effect of temperature on the centre frequency.

In some applications, the temperature characteristic may not require specific compensating. However, it may be the case, such as when utilising the arrangement 1 of Fig. 1, that the fibre is still required to be packaged under strain so as to achieve a greater wavelength accuracy than that which can be achieved in the fibre writing process.

In the majority of packaged Bragg fibre gratings, the fibre is held under strain. When fixing the fibre to the package, a number of techniques may be employed. These include epoxy adhesive or glass "fritting". These processes often require heat and as a result, they can have a further effect on the wavelength of the grating making it difficult to distinguish between the effects of strain or heat when setting the fibre in the package and setting the corresponding wavelength. Further, typical methods for fixing the fibre to the package may have some shrinkage effects as either the epoxy cures or the glass frit sets. The shrinkage can further introduce unwanted changes to the strain on the fibre which result in an alteration of the wavelength setting.

Further, the materials utilised often require that an epoxy resin or the like is used to affix the fibre to the package. This can induce the problem of creep wherein, over time, the characteristics of the wave guide change due to creep of the adhesive material relative to the package or to the fibre. Unfortunately, epoxy can be undesirably humidity sensitive. The unavoidable use of an epoxy is often required to be utilised due to the necessity to maintain compatibility of materials.

Summary of the Invention

It is an object of the present invention to provide an improved temperature stable optical fibre package.

In accordance with a first aspect of the present invention, there is provided a method of accurately setting the centre wavelength of a fibre grating fixed in a temperature compensation package, the method comprising the steps of fixing the grating to the package and altering the size of the package in a post processing step.

The altering step can comprise elongating or compressing the package so as to substantially permanently alter the size of the package.

The temperature compensation package can comprise a first member having a first coefficient of thermal expansion; two second members, one each attached to the ends of the first member and having their other second ends closer together then the ends of the first member, the second members having a second coefficient of thermal expansion relatively more then the first coefficient of thermal expansion; and two material matching members attached to the second ends and adapted to provide for material matching fixing mixtures to the second members; said fixing mixtures fixing ends of the fibre grating to the temperature compensation package.

The fixing mixture can comprise glass or metal solder.

The material matching members are preferably located within an aperture in the second ends.

In accordance with a further aspect of the present invention, there is provided a temperature stable grating package having an accurately fixable centre frequency, the package including: fixing means for fixing a grating fibre to the package; temperature compensation means for compensating for any fluctuations in temperature of the package; and package length alteration means for altering the length of the package so as to accurately and

substantially fix the centre frequency of the grating.

The temperature compensation means can comprise: a first member having a first coefficient of thermal expansion; two second members, one each attached to the ends of the first member and having their other second ends closer together then the ends of the first member, the second members having a second coefficient of thermal expansion relatively less then the first coefficient of thermal expansion; and two material matching members attached to the second ends and adapted to provide for material matching fixing mixtures to the second members; and the fixing means fixing ends of the fibre grating to the temperature compensation package.

The fixing means comprise glass or metal solder and the material matching members can be located within an aperture in the second ends.

In accordance with a further aspect of the present invention, there is provided a temperature stable grating package including: fixing means for fixing a grating fibre to the package; temperature compensation means for compensating for any fluctuations in temperature of the package; wherein the temperature compensation means can comprise: a first member having a first coefficient of thermal expansion; two second members, one each attached to the ends of the first member and having their other second ends closer together then the ends of the first member, the second members having a second coefficient of thermal expansion relatively less then the first coefficient of thermal expansion; and two material matching members attached to the second ends and adapted to provide for material matching fixing mixtures to the second members; and the fixing means fixing ends of the fibre grating to the temperature compensation package.

The fixing means can comprise glass or metal solder.

Brief Description of the Drawings

Notwithstanding any other forms which may fall within the scope of the present invention, preferred forms of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Fig. 1 illustrates a simple grating package as utilised in the prior art;

Fig. 2 illustrates a temperature compensation package as known in the prior art; and

Fig. 3(a) and Fig. 3(b) illustrate schematically the structure of the preferred embodiment.

Description of the Preferred and Other Embodiments

In accordance with the preferred embodiment of the present invention there is provided an apparatus for providing a tunable Bragg grating with the apparatus separating the problem of setting the centre wavelength from that of fixing or mounting the fibre to the package. This is achieved by first fixing the fibre to the package and then applying a post fixing "tune" so as to tune the wavelength of the grating in accordance with requirements.

Further, through the utilisation of an intermediate material which has a coefficient of thermal expansion similar to the glass fibre and a supporting platform and is also compatible for the use of glass or metal solder the problem of the difficulty in utilising epoxy or polymer adhesives, especially in their sensitivity to humidity, is alleviated and an improved package results.

Turning now to Fig. 3(a) and Fig. 3(b), there is illustrated one form of the preferred embodiment with Fig.3(a) showing a side sectional view and Fig. 3(b) showing a top sectional view. The preferred embodiment 20 is designed to maintain a previously written grating 21 on a fibre 22 in a highly stable environment such that the grating frequency can be readily set. The package 20 includes two end portions 23, 24 made of a first material,

such as stainless steel, having a high coefficient of thermal expansion. A second cylindrical member 25 is provided and, importantly, includes a thinned section 26 which is provided for post tuning of the wavelength.

Each of the members 23, 24 include a cylindrical hole in which is mounted a Kovar platform e.g. 27, 28. The Kovar platform can be slotted into a hole formed in the corresponding member 23, 24. The Kovar platform e.g. 27, 28 provides for a material matching capability between the Kovar platform and a solder material 29, 30 which is utilised to affix the fibre 22 to the package. In this way, the necessity to utilise a polymer adhesive can be dispensed with providing for longer term stability.

Of course, many different materials can be utilised for the platform 27, 28. For example, Kovar or invar may be utilised, zirconia ceramic and some other silica materials could be utilised. Ideally, each member e.g. 26, 23, 24 and 27 and 28 are laser welded together where laser welding is suitable.

The arrangement 20 thereby provides for the utilisation of a glass or metal solder (frit) and eliminates the need to utilise any polymer adhesive thereby reducing the effects of long term creep and providing for higher long term stability.

The first step of the preferred embodiment therefore comprises manufacturing the package arrangement and fixing the fibre 22 in place. The wavelength setting at this stage is not critical but is preferably lower than that desired in the final device.

After the fibre has been fixed and any post fixing shrinking has occurred, the package 20 can be expanded or compressed in an axial direction. The stretching can be achieved by a controlled force around a thinned portion 26 so as to permanently elongate the package. Alternatively, compression can be utilised to compress the size of the

package. Preferably, the packages constructed from such materials as steel, kovar or invar which can be plastically deformed. The deformation achieves a permanent change in length which in turn alters the strain on the optical fibre Bragg grating in middle area 21 thereby varying the centre wavelength.

It has been found in practice that the range of increase in length required to provide a full range of tuning for most applications is typically less than 5μm. The post tuning operation is preferably carried out at the temperature of operation of the device thereby providing a resulting package which provides an accurate wavelength at a given temperature irrespective of the residual characteristic of the device across a temperature range.

It would be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiment without departing from the spirit or scope of the invention as broadly described. The present embodiment is, therefore, to be considered in all respects to be illustrative and not restrictive.

We Claim:

1. A method of accurately setting the centre wavelength of a fibre grating fixed in a temperature compensation package, said method comprising the steps of:

fixing said grating to said package; and

altering the size of said package in a post processing step.

2. A method as claimed in claim 1 wherein said altering step comprises elongating or compressing said package.

3. A method as claimed in any previous claim wherein said altering step substantially permanently alters the size of said package.

4. A method as claimed in claim 1 wherein said temperature compensation package comprises:

a first member having a first coefficient of thermal expansion;

two second members, one each attached to the ends of said first member and having their other second ends closer together then the ends of said first member, said second members having a second coefficient of thermal expansion relatively more then said first coefficient of thermal expansion; and

two material matching members attached to said second ends and adapted to provide for material matching fixing mixtures to said second elongated members;

said fixing mixtures fixing ends of said fibre grating to said temperature compensation package.

5. A method as claimed in claim 4 wherein said fixing mixture comprises glass or metal solder.

6. A method as claimed in claim 4 or claim 5 wherein said material matching members are located within an aperture in said second ends.

7. A temperature stable grating package having an accurately fixable centre frequency, said package

including:

fixing means for fixing a grating fibre to said package;

temperature compensation means for compensating for any fluctuations in temperature of said package; and

package length alteration means for altering the length of said package so as to accurately and substantially fix the centre frequency of said grating.

8. A package as claimed in claim 7 wherein said temperature compensation means comprises:

a first elongated member having a first coefficient of thermal expansion;

two second elongated members, one each attached to the ends of said first elongated member and having their other second ends closer together then the ends of said first elongated member, said second elongated members having a second coefficient of thermal expansion relatively less then said first coefficient of thermal expansion; and

two material matching members attached to said second ends and adapted to provide for material matching fixing mixtures to said second elongated members; and

said fixing means fixing ends of said fibre grating to said temperature compensation package.

9. A method as claimed in claim 8 wherein said fixing means comprises glass or metal solder.

10. A method as claimed in claim 8 or claim 9 wherein said material matching members are located within an aperture in said second ends.

11. A temperature stable grating package including:

fixing means for fixing a grating fibre to said package;

temperature compensation means for compensating for any fluctuations in temperature of said package; wherein said temperature compensation means comprises:

a first elongated member having a first coefficient of

thermal expansion;

two second elongated members, one each attached to the ends of said first elongated member and having their other second ends closer together then the ends of said first elongated member, said second elongated members having a second coefficient of thermal expansion relatively less then said first coefficient of thermal expansion; and

two material matching members attached to said second ends and adapted to provide for material matching fixing mixtures to said second elongated members; and

said fixing means fixing ends of said fibre grating to said temperature compensation package.

12. A method as claimed in claim 11 wherein said fixing means comprises glass or metal solder.

13. A method as claimed in claim 11 or claim 12 wherein said material matching members are located within an aperture in said second ends.

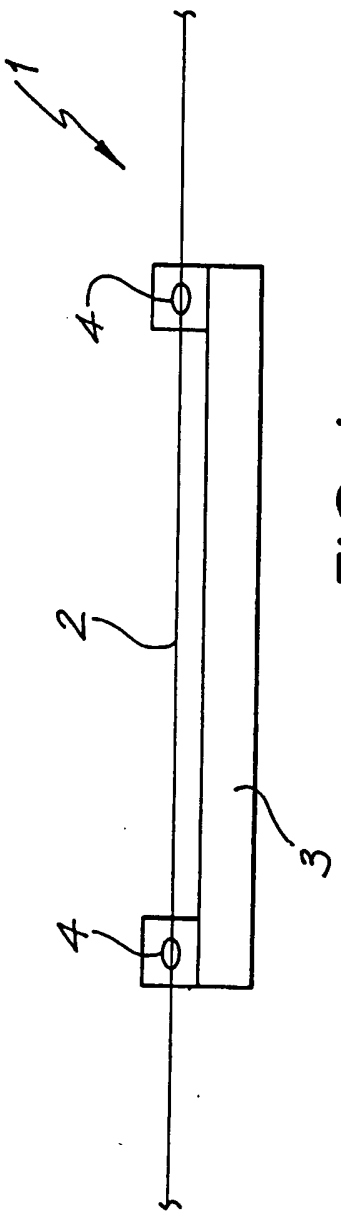


FIG. 1 PRIOR ART

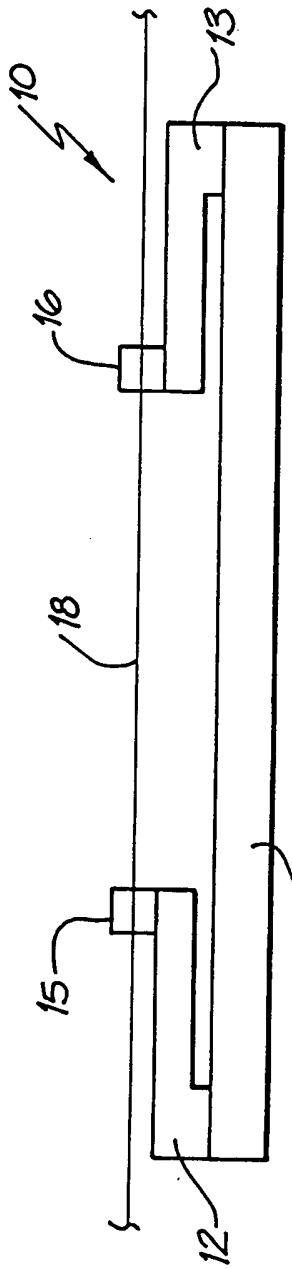


FIG. 2 PRIOR ART

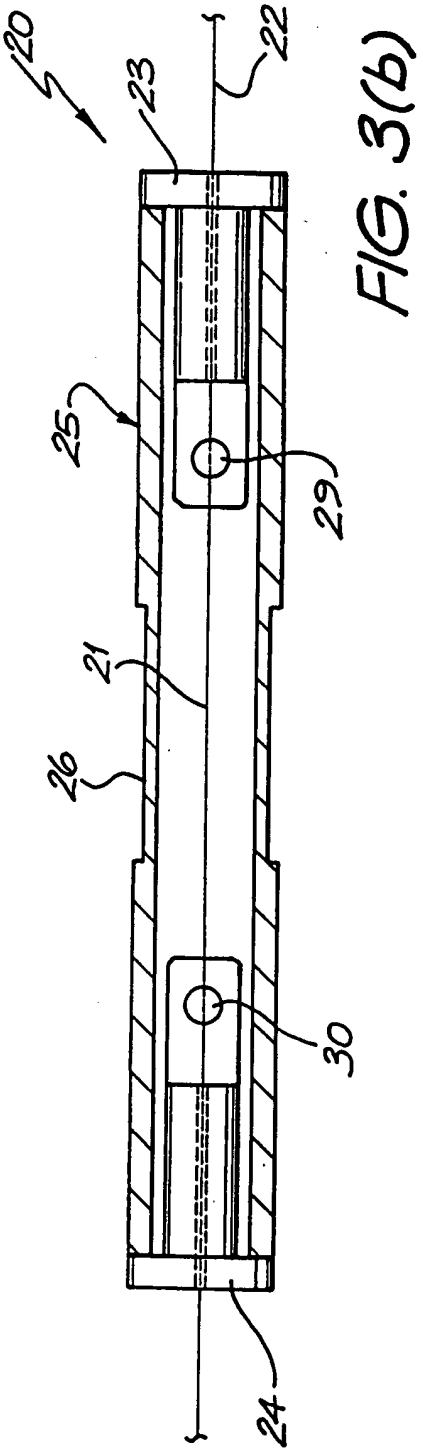


FIG. 3(b)

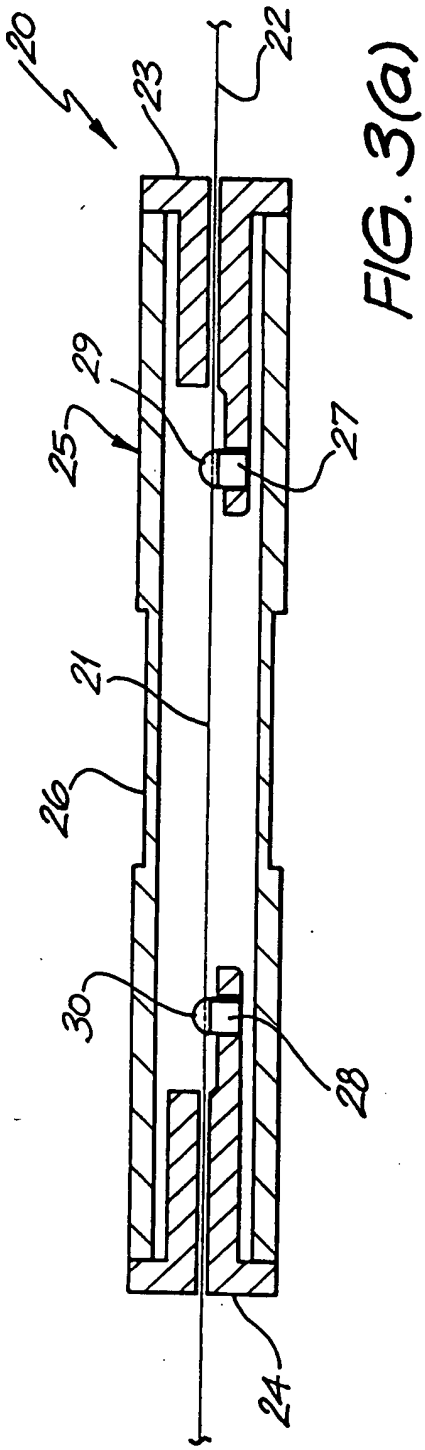


FIG. 3(a)

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 98/00473

A. CLASSIFICATION OF SUBJECT MATTER

Int Cl[6]: G02B 5/18, 6/16, 6/293, G02F 1/225

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC G02B 6/16, 6/293

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
WPAT: fiber or fibre and grating
JAPIO: fiber or fibre and grating

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X, Y	WO 95/30926 A (UNIVERSITY OF SYDNEY) 16 November 1995 page 10 lines 1-27, figure 5	1-3, 7
Y	US 5367589 A (MACDONALD et al.) 22 November 1994 column 5 line 37 - column 6 line 10	1-3, 7
X	US 5613023 A (GUILLON et al.) 18 March 1997 column 4 lines 1-9	1-3, 7
X	WO 91/10151 A (UNITED TECHNOLOGIES CORP.) 11 July 1991 page 8 line 4 - page 14 line 10	1-3, 7

[X] Further documents are listed in the continuation of Box C

[X] See patent family annex

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 July 1998	13 JUL 1998
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimile No.: (02) 6285 3929	Authorized officer PHILIP SPANN Telephone No.: (02) 6283 2178

INTERNATIONAL SEARCH REPORT

International Application No.
PCT/AU 98/00473

C (Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X, P	Derwent Abstract Accession No. 97-461329/43, class V07, JP 09-211348 A (SUMITOMO ELECTRIC IND) 15 August 1997 whole abstract	1-3, 7